Menlo Park Notebook [N-80-02-16] (unnumbered)

This notebook covers the period February-March 1880. There is also an entry for July 1880. All of the entries are by Edison and Francis Upton. Included are notes and drawings relating to lamp experiments and to photometric tests of lamps. The book also contains Edison's description of the ideal lamp and Upton's notes on meter and dynamometer tests. There are two labels marked "Photometer" and "Feb 1880." The bottom part of the label containing the Menlo Park notebook number has been torn off. There is an index on the inside front cover. The book contains 284 numbered pages.

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Carbons-small paper loops
61, 79, 186.

F264 16 1880

"

Coating a carbon with a paste of
Zirconia oxides with alcohol.
caused the Zr. to melt and contract
and put a tension on the carbon which
broke it & think some of the oxide

small horseshoe used – gave pro

gas jets – the fluorescence wa

strongest we have yet seen

A — Index

Analysis of Carbons tested — 1, 3, 5, 7, 9,
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May ____, 189_

Commercial ...
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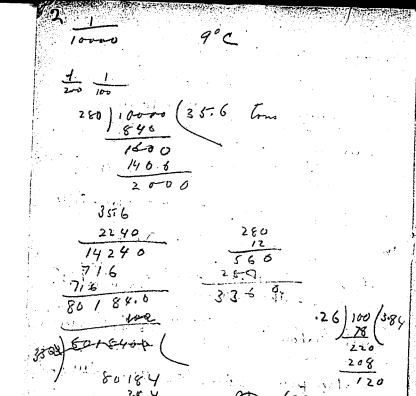
Carbons — Small paper lamps
61, 79, 106.

Feb 4 1880 1

"

Coating a carbon with a paste of zirconia oxides with alcohol caused the Zr. to melt and contract and put a tension on the carbon which broke it. I think some of the oxide was reduced by the carbon but am not sure - The zirconia was coated with carbon in some places jet black in other places only browned - The lamp was brought to bear incandescence small horseshoe used - gave probably gas jets - The fluorescence was the strongest we have yet seen



being intensely violet. This seems to show that the fluorescence is not entirely due to the molecular impact on the glass. - The appearance of the oxides on examination under the microscope resembled paste which had dried contracted and cracked. where the arc formed there was vitrous fusion

The same size of carbon was coated in the same way with alumina this was immediately reduced by the carbon at high incandescence and destroyed it. This is another

24·7
1·75
1285
1799
257
45·85

3456 (775
315
336
315
210

Rowlands value

9·5 17·5

confirmation of my idea that metallic aluminium may be produced cheaply from the oxide by packing it around exhausted long thick sticks of carbon and exhausting the tube and rendering the carbon incandescent by the current from the Faradic machines no fluorescence, as it was destroyed before highest temperature reached

The caused of the formation of a long crack and the subsequent breaking of a chip of the glass by the action of the pressure of the atmosphere is undoubtedly

due to the sudden heating of the platina wires passing through the glass especially when the wires are small and the resistance of the carbon small, with .010 wire and 78 ohm (cold) lamp. Slowly putting on current did not cause a crack whereas when the glass was cold the sudden putting on of the current caused the lamp to be instantly destroyed by the formation of a crack which

so weakened the glass that the pressure of the atmosphere was sufficient to break of a piece of the glass and project it into the vacuum -

The same cause is active when an arc springs across between the clamps which if it does not have sufficient power to melt the wire is sufficient to give a sudden accession of heat to the platina wires, and thus cause a sudden expansion cracking the glass.

I have noticed that when tungsten rita clamps, or any clamp made of carbonizable material is used that on reaching high vacua and heating that a gas comes out of the clamp and lowers the vacuum and this will continue for hours, if there is much gas there will appear a blueish halo shooting out from the carbon (one side only) near the clamp. this gradually increases until there suddenly springs a blueish arc between the clamps and of the circuit

is not immediately broken an
appearance of this are the wires
will be fused, on destroying the
are no matter how quickly after
its formation the clamps will be
found to be red hot. this in its
turn tends to cause more gas to
flow out of the clamp and reduce
the resistance and augument the
size of the arc = as the arc has
small illuminating power although
between carbon clamps I take
it that it is entirely gaseous

and that it is carbonic oxide or
carbonic acid gas, when this are
is formed I notice ~~that the glass~~
near the clamps is blackened in
the same way as the whole of the
globe is by the long continued
action of the lamp. ~~And~~ The platina
leading wires ~~to~~ which the carbon
clamps are screwed even when
there has been no perceptible arc
are coated with carbon just
like lamp black. For a space

of 1/4 of an inch, the clamps
instead of being shiny are black
and in fact the whole fibre
has this coaly deposit as the
great drop shown by the McLeod
gauge when the first heating
takes place and the long continuance
of the drop when the carbon
remains heated notwithstanding
the action of the sprengil shows
that the gas must be in a condensed
form and great in quantity and

If it be carbonic oxide, it must have a very pernicious effect. Hence I think that the smallest possible carbon clamps should be used if used at all and some means should be used to heat the clamps before the fibre or horseshoe is heated so that the air or gas may be abstracted by the pump before it has a chance to act upon the lamp but the best clamp would undoubtedly be platinum Iridium alloy of

the smallest dimensions —

I have noticed that the glass of nearly every lamp especially those which have shown fluorescence has a mottled appearance, the polish being taken off where the spots are and these spots are more whitish than the rest of the glass. It may be that there is material or Cambardment or it may be that the carbonic acid has combined with the [illegible] of glass.

and after all have combined
it is decomposed again by
impact as it combines and
any further Carbonic acid
is decomposed but this is a
far fetched supposition.

~~the carbon to the platina~~
~~Clamp [illegible] set that down~~

Photometric tests.

March 7, 1880. TAG

Large sized kerosene burner chimney clean

10h 45' 53"		410 grains
10h 48' 15"		400 grains
10h 48' 20"		380 grains

45 53.
3 2
150
207 : 210 :: 120 : 121

53.3
267) 53.3 (2
53.4

2
2
4
2

Good flame. 8 candles

Very large flame nearly smoking

5·5·1

249) 5·5·1 (2.21
498
530
498
320

2.21
2.21
221
442
442
488841
2
9.76 candles

Mackenzie's lamp
full flame

5·46

254) 5·46 (2.14
508
380
254
1260
1016

2.14
2.14
856
214
428
45796
2
9.15 candles

9.15 Candles

Thin side kerosene

49.8

312) 49.8 (.1

312

86

Ans

E. L.

$\frac{260}{3}$ Volts

555.2

248) 555.2 (222

496

560

496

640

222
222
444
444
444
49284
2
9.85

30

$\frac{61}{61}$

$\frac{615}{6}$

$3782 - 25$

615

185) 615 (33.1

555

600

585

450

469

3.31

616

184) 616 (33

552

640

552

980

163) 617 (3.5

549

680

549

1310

90 Volts

58.5

.215) 58.5 (272 TPH

430

1550

1505

450

272

272

544

2064

544

73984

2

14.99

250 Volts

61.2

18.8) 61.2 (3.26

564

480

376

1040

326

326

1956

1652

9778

106276

2

21.2

31

62.25

17.75) 62.25 (3.5

53.25

9000

8875

1250

3.5
3.5
175
105
1225
2
24.4 candles

100 Volts

63

17) 63 (3.7

51

120

119

3.7
3.7
259
111
1369
2
27.3 Candles

34

285 ?

TAG 35

59.75

2025) 59.75 (295

4050

19250

18205

10450

295

295

1495

2655

590

87045

2

17.4 candles

285 Volts

3

60.25

1975) 6025 (30

5925

1000

18 candles

60.75

19 25 / 60.75 (3.15

5 8 7 5

3 0 0 0

1 9 2 5

1 0 7 5 0

3.15

3.15

1565

21.15

405

79215

19.8

---

172 : 185 :: 93.5 : 94.5

175

4675

6545

935

172) 8362 5 (94.5

1548

882

688

3 | 2853

94.5

94.5) 3950000 (4177

3780

1700

945

7550

6615

935

4177) 33000 (8. μ H.P.

33388

38

$12^h\ 33'\ 28''$
$12\ 44\ 45$
$\cancel{45}$
$11\ 17$
$\cancel{60}$
677

1770 grains
1725
45

16) 4177 (260
32
97
96

260 ft.

4177 ft. lbs. 39

TAG

622
178) 622.2 (3.5
534
880

3.5
3.5
175
105
1225
2
24.5 Candles

Same ft lbs

60.9
191) 33.9.0 (318
573
350
191
1690

3.18
3.18
2544
318
954
101.124
2
20.2 Candles

40

$V^2 = n(R-x)^2$

$= 6400n - 160nx + nx^2$

$(n-1)x^2 - 160nx = -6400n$

$x^2 - \frac{160n}{n-1} = -\frac{6400n}{n-1}$

59 58 11 1/11 41

21

$x = \frac{80n}{n-1} \pm \sqrt{\left(\frac{80n}{n-1}\right)^2 - \frac{6400n}{n-1}}$

$n = 11$

$\frac{880}{10} = 88$

704
704
744
7040
704.

704
704
7744
7744
0

88
24.9
631

88
26.5.7
6147

22 candles

43
160 Ohms
730 Candlestands 22/7
75.4

4311) 33000 (7.6 per Kt. 10
30177
28230
25866
2364 40
22 candles

4311 ft

4311
4311) 4341196 (
4311
3039
3021
1186
1078
108

160 on lamps
175 on resistance
43
TAF

3) 297
99

169 Lamp
183 Resistance

169 ! 182 :: 93.5
935
916
546
1638
169) 17017 0. (100.7
169
1170
16) 4311 (270
32
111
112

270 ft. lbs. per candle

44

56·3
237) 56·3 (237.
474
890
711
1790

2
561
2
1122 Candle

3700 / 33000 (8.91
29600
3400
3206
1940

R calcd = 190 Ohms
Fibre
56·3
100 Volts

142 lamps

1421 182 :: 93.5
182
1876
7480
935
142) 170170 (1198 Ohms
142
281
142
1390
1278
1120

1198) 443000 (3700
3594
8360
386

46

$$\begin{array}{r} 54.25 \\ 2575 \overline{)\,5425} \\ 5150 \\ \hline 3750 \\ 2575 \\ \hline 1175 \end{array} \quad (214 \text{ TAP } \times 4)$$

$$\begin{array}{r} 4579 \\ \times\ 2 \\ \hline 9,158 \end{array}$$

Side 9,1 Candles

10.5 Candles average

$$\begin{array}{r} 10.5 \overline{)\,370.0} \\ 315 \\ \hline 550 \\ 525 \\ \hline 250 \end{array} \quad (35.2.$$

35.2 ft. lbs. per candle

hard filter

48

16) 4388 (ft. lbs.
32
118
112
60
273

38315-0

87.3) 38315.0 (4388
3492
3395
2619
7760
7604
75-40

4388) 33000 (7.5 per H.P.
30716
22840

180 Ohms c/d Regulay Large Lamps
2500 Volts
3
93
22 candles Brownside

179 Lamps
167 on 93.5 Ohms

167 : 179 :: 93.5
179
4415
6545
935
167) 167365

179 : 167 :: 93.5
167
6545
5610
935
179) 15614.5 (87.3 Ohms
1432
1294
1233
615

50

64.75

1525) 64.75 (423
6100
3750
3050
700

17.9
2
35.8 Candles

858) 4429000 (5163. ft. lbs
4290
1400
858
5420
5148
2720

35.8) 51630 (1441 lbs
7
2506
358
1583
1432
1510

for candle from bench side

25) 5163 (205 ft. lbs per candle
50
163

51

100 Volts

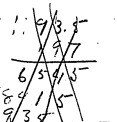
Regulus

64.75 P

197

Tide

181 : 197 : : 93.5



181) 18497 (102

197 : 181 : : 93.5
181
435
7480
935

197) 169235 (858 Ohms
1576
1163
985
178 0

52

206) 33000 (160
206
1240
1236
40

160 candles per H. P.

---

10 of 16 candles
each of the same surface
to work

5162) 33000 (6.39 per H. P.
30978
20220
15489
47310

53

Impact 6.39
10

THE

3 inches long

.63	7.6	6.4
.63	7.6	6.4
	456	256
	532	384
	5776	4096

41 : 58 :: 16 :
16
348
58
41) 928 (22.6
82
108
82
260

54

545
255) 545 (2.13
510
350
255
950

4.5.3
2
9,0 6
2
18.

18) 2079 (115
18
27
18
99

16) 2079 (129.
16
47
32
159
144
150

130 ft thousand

53

100 Valdes

5415 Photo.

78 | 182 | 93.5
18.2
1870
7480
935
78) 17017.0 (218.
156
141
78
637

218) 443000 (2079 ft Ellen
436
1700
44

13

over

56

130) 33000 (254.
260
7700
650
500

16) 254 (16 per H.P.
16
94

Another fibre 57

56 on lamps
162 on 93.5 Tap
270/3 = 90 Volts

Photo 37

56 : 162 :: 93.5
162
1870
5710
935
56) 15247.6 (272
112
404
392
127
112
150

over

37

43) 37.0 (.86

344

260

258

.739

1.47

272) 358830 (1319 ft. lbs.

272

868

816

520

272

2480

Manilla Ybor

100 Volts

65 on lamp

182 on 93.5 T.F.

Photo 45

65 : 182 :: 93.5

182

1870

7480

935

65) 17031.0 (261 Ohms

130

401

390

117

65

over

60

Manilla fibre

45
35) 45 (1.28
35
100
90
300
10

163
2
326 candles

261) 443000 (1700 ft lbs
261
1820

3) 1700 (566 ft lbs.
15
20 per candle

Small paper loops 61

250 / 3 = 83.3 Volts

110 on lamp fair.

1.54 on 93.5

110) 154 (1.4
110
440
440

93.5
1.4
3740
935
1309 ohms

52.5 Volts 7.3 candles

10.7 : 15.1 :: 93.5 : 131.9

14.1
935
4675
935
10.7) 141.85 (13.19
107
341
321
198
107
91.5

$5^{-}2.5^{-}$

$275\overline{)52.5^{-}}$

833 6938

1152

2786

2502

2842

2750

92

$130.9\overline{)}$ 3317 = 25.45 lb lbs

2618

699

654

45

$\frac{260}{3}$ ~~Volts~~ = 86.6 Volts Eg.

~~Log~~ on lamp

112

$U_{2.3}$ ~~115~~ on 93.5

158

$5^{-}4.75$ ~~Photo~~

$112\overline{)158}$ (1.41

112

460

448

120

112

93.5

141

935

3740

935

131.835

93.5

141

935

1870

2805

935

$1\,31.5\,20$ Ohms

85.6

7412

513

6899

3299

2799

500

2.336

.5466

.5272

540

10344

1396

2 - 90 Ohms

Starting 3 candles from 200 ft. lbs.

$2^3 = 8$

$25 = 8\overline{)15.6}$
19
3
57

$8\overline{)27}$
3.37
3
1011

$3.5^3 = 8\overline{)42.8}$
5.35
3
1605

$\therefore 24$

60 Volts

TR

126 on lamp
119
$\frac{1}{2}=.5$ 120
163

56.25 Photo 11.25

119)163(1.37
119
440
357
830

93.5
13.7
6545
2805
935
128.095 Ohms

443
8100
443
3544
$128\overline{)358830}$ = 2800 ft. lbs.
256
1027
1024

78.4
460

69

$\frac{280}{30} = 93.3$ Volts

69

Tip

~~173~~ 126 on lamp

0=.3 ~~166~~ 169 on 93.5 ~~Ohms~~

59 Photo 15.8 candle.

126 | 169 | 134
126
430
378
520

93.5
134
3740
2800
935
12524.0

8705
44.3
26115
34820
34820
3886315 | 3080 ft. lbs
3756
10031

$\frac{290}{3} = 96.6$ volts

$0 = .3$ ~~43.2~~ on lamps Tap
~~135~~
~~174~~ on 93.2
174

61.25 on Points = 21.1 candles

135 | 174 (128
135
390
270
1200

93.5
128
7480
18700
935
119.680

9822
44.3
27996
3273
37328
197 | 4134607 = 245 + 117/197
3591
5430
4788
6420
5985
4350

100 Volts.

144 on lamps
144
478 on 93.5
181

62.75 Phots.

144)187(1.26
144
370
288
820

935
1.26
3810
1870
935
1176.10 Ohms

116)443000(3818 ft lbs
348
950
928
220
116
1040

3818)33000(8.6
30544
24560

62.75
1725 | 62.75 | 3.63
5175
11000
10350
6500

363
367
989
2178
989
12.1659
2
243 candles
7
1701 all round

16 | 3818 | 238
32
61
48
138

17 | 3818 | 224 ft lbs to candle
34 all round
41
34
78

$\frac{240}{3} = 80$ Volts

TAP

49 Photo = 5 candles

0=0

111 on lamp

148 on 93.5

1.33 3

111 | 148 | 1.33 2805
111
370
333
370
2805
935
1243.55 ohms

6400
443
9266
25600
256
1249 | 2855.05 | 2.29 ft lbs
2494
3470
3245
9520
8708
1111

$\frac{230}{3} = 76.6$ Volts

104 on lamps

0=D 140 on 93.5

45 on Photo = 3.4 candles

104)140(134 93.5 / 134 / 3840 / 2805 / 935 / 12539.0

5565 / 44.3 / 17604 / 23472 / 23472. / 2593.4 ft. lbs.

258)259952(
2580
1558
1548
3720

$\frac{220}{3} = 73.3$ Volts

97 on lamp
134 on 93.5

.41.5 Photo = 2.2 candles

97)134 (1 134
97
340
291
490

93.5
1.34
3740
2805
935
125.290

5373
443
16119
21492
21492
1253)2350 = 3 0 1849 Volts.
1253
1124
10024
12483
11277
1206

Small loop taken
No. 810 Glass well
cleaned

$\frac{200}{3} = 66.6$ Volts

86 on Lamp
122 on 93.5 Ohms

31.5 Photo. = 1 candle

86) 122 (1.42
88
360
344
16.0

93.5
142
1870
3740
935
13270 Ohms

4436
4436
13308
17744
17744

1325) 1465148 (1478
1325
6271
5300
19648
18550
1098

70 Volts

93 on lamp

127 on 93.5

36.5 = 1.12 candles

93)127(1365

93

340

279

610

558

520

93.5

136

5610

2805

935

12616.0

44.3

4900

3387 00

1772

1269)2110700(1670 Volts

126

850

756

947

March 21st 1887

88

Best conditions.

Large bulb.
Most proportionate and correctly bulb.
small leading wires through glass
annealed glass where the wires pass,
High polish where wires pass through glass
Perfect cleaning of the tubes before blowing
A glass containing nothing that will
combine with Carbonic acid.
To heat the bulb the least bath
for convenience in handling and for
the prevention of chemical combination
platinum iridium clamps.
Clamp the conductor firmly with
a clamp that will spring together

and hold tight whether it expands or
the Carbon wastes,
No iron or other material that contains
much gas to be used in lamp.
Double sealing.
Heating the bulbs by sand bath
when exhausting.
Very gradual putting on of current
so that most of the gases are
driven off at invisible heat,
place the clamps some distance
apart,
Carbonize without oxidation and at
highest practicable temperatures.
Have the Carbons flat if possible

The highest resistance combined with the smallest radiating surface,

Even resistances.

88

89

.723 Volts

99 on lamps
133 on 93.5

41.75 = 24 candles

99) 133 (134
99
340
297
43

93.5
134
3736
2805
935
12528 Ohms

5373
443
16119
21492
21492
2380.239 (190 Ω
1253
1127

$\frac{230}{3} = 76.6$ Volts

105 on Lamp

140 on 93.5

46.25 = 3.8 candles

105)140(1.33
105
350
315
350

93.5
1.33
2805
2805
935
124.355 Ohms

5868
46.3
17604
23472
23472
271592
1244 | 2715.92 = 2.180 Ohms
2.488
2272
1076

80 Volts

111 on lamp

147 on 93.5

49.75 Photo = 5.4 candles

111) 147 (132
111
360
333
270

93.5
132
1870
2805
935
12340

493
64 00
1772
2658
123) 28350 (2305
246
372
369
30

~~632~~ Volts

84 Volts

118 milliamps

153 on 93.5 ohms

52.5 ~~Photo~~ Volts.

= 7.5 candles

118)153(1.3
118
350
354

935
1.3
2805
935
121.55

7056
443
21168
25224
28224
3125508 (2560 ft lbs.
122
244
685
610
750
732
180

$\frac{260}{3} = 86.6$ Volts

123 on lamps
125
15.8 on 93.5 TM

5-4 Rhats.
5-5
5-5.25
= 9.5 candles

443
500
2215
3101

118) 3.32.50 (2810 ft. lbs
236
962
944
180

124) 158 (1.26
124
340
248
920

93.5
1.26
5610
1870
9350
11781

98

99

90 Volts

TAG

132 en Campo

165 en 63.5

57.5 = 12 grandes

93.5 × 1.24 = 3740 + 1870 + 935 = 115.94 ohms

132) 165 (1.24
132
330
264
660

93.5 × 1.24 = 25410 + 1270 + 635 = 8740

443 × 8100 = 3590 ft. lb.

443
3542
3542
116) 3583 (30.9 ft. lb.
348
1053
1044

100

101

93.3 Volts

TLG

140 on lamp
139

172 on 93.5

59.25 = Photo = 16.2 candles

$$140\overline{)172}\,(1.22 \qquad \begin{array}{r} 93.5 \\ 122 \\ \hline 1870 \\ 1870 \\ 935 \\ \hline 114070 \end{array}$$

$$\begin{array}{r} 140 \\ \hline 320 \\ 280 \\ \hline 400 \end{array}$$

$$\begin{array}{r} 8705 \\ 443 \\ \hline 26115 \\ 34820 \\ 34820 \\ \hline 3856315 \end{array} \quad (=3822 \text{ Watts})$$

$$14\overline{)3856315}$$

$$\begin{array}{r} 342 \\ \hline 436 \\ 342 \\ \hline 940 \\ 912 \\ \hline \end{array}$$

102

96.6 Volts 103

146 on Candle 119
147
147 on 93.5

60.25 Photometer 19 candles

146) 177 (121
146
310
292
180

93.5
121
935
1870
935
11313.5

9332
403
27996
37328
3732.8
113) 7113 - 076 (3660 Ohms.
339
744
678
660

4000
403

1.4
200
25 amps
1.4
2
4
3

= 22.5
12

100 Volts

156 on lamps
183 on 93.5

62 Rheostat = 23.5 candles

156) 183 (117
156
270
156
1140
1092
480

93.5
117
5545
935
935
10839 5

108.39) 443 amps (4080 ft lbs
43366
9400
1336

4080) 33 amps (8.
3264
360

106 Summary Small paper book No. 1.

Candles	Resistance	Volts	Ext. Cs
7.3	130.9	83.3	2348
9.2	131.8	86.6	2490
11.25	128.	90	2800

107

$$x = \frac{80n}{n-1} \pm \sqrt{\left(\frac{80n}{n-1}\right)^2 - \left(\frac{6400n}{n-1}\right)}$$

$n = .5$

$80n = 40$

$n - 1 = -.5$

6400

$\cdot 5$

$3200.$

$\frac{80n}{n-1} = -80$

-80

6400

6400

$\sqrt{12800} = 113.$

80

33

27

Taf

1088

2269

1 candle 38

2 " 40

108

$$x = \frac{80n}{n-1} \pm \sqrt{\left(\frac{80n}{n-1}\right)^2 - \frac{6400n}{n-1}}$$

$n = 1.5$

$\frac{80}{120.0}$

240

6400 (1.5)

32000

6400

96000

2

19200

$\frac{80n}{n-1} = 240$

240

96000

48

576000

192000

384000

240

199.9

461

3 candles $x = 46.1$

109

$n = 2$

$160 \pm \sqrt{160^2 - 12800}$

$160^2 = 25600$

12800

12800

160

11 31

409

$\frac{160}{6400}$ ± 4 candles

2

12800

TNE

110 $x = \frac{80n}{n-1} \pm \sqrt{\left(\frac{80n}{n-1}\right)^2 - \frac{6400n}{n-1}}$

$x = 2.5$

$x - 1 = 1.5$ $\quad \frac{n}{n-1} = \frac{5}{3}$

3 | 400
133.3

17800
10666
7134 (84.4
64
164 | 734
656
780

3 | 5000
1000
2000

6400
5
3 | 32000
10666.

133.3
84.4
48.9

5 candles

111

$n = 3$ $\quad \frac{80}{3}$ $\quad 240$

$x - 1 = 2$

$\frac{80n}{n-1} = 120$

14400
9600
4800
120
69.28
50.72

6400
3
17200
9600

Tag

6 candles

$x = 3.5$

$x - 1 = 2.5$

3.5
80
28000
11200
12544
8969
3584 (59.1
25
109 | 1081
981
118) 1700

6400
3.5
32000
19206
2240.000
4
8960.0

2.5 | 591

112
59.1
529.

7 candles

$x =$

$$\frac{80n}{n-1} \pm \sqrt{\left(\frac{40n}{n-1}\right)^2 - \frac{6400n}{n-1}}$$

$$\pm \sqrt{\frac{6400\left(n^2 - n + 1\right)}{(n-1)^2}}$$

$$\frac{80n \pm 6400}{n-1}$$

$$\frac{80(n \pm 80)}{n-1}$$

$$\frac{dn}{n-1} \pm \sqrt{\left(\frac{dn}{n-1}\right)^2 - \frac{d^2n}{n-1}}$$

$$= \frac{dn}{n-1} \pm \sqrt{\frac{d^2n^2 - d^2n + d^2n}{(n-1)^2}}$$

$$= \frac{dn}{n-1} \pm \frac{d\sqrt{n}}{n-1} = \frac{d(n \pm \sqrt{n})}{n-1}$$

$$= d$$

$$x^2 = ba(d-x)^2$$

$$x^2 = ba\,d^2 - 2ba\,dx + ba\,x^2$$

$$(ba-1)x^2 - 2ba\,dx = -ba\,d^2$$

$$x^2 - \frac{2ba\,dx}{ba-1} + \left(\frac{ba\,d}{ba-1}\right)^2 = -\frac{ba\,d^2}{ba-1} + \left(\frac{ba\,d}{ba-1}\right)^2$$

$$= -\frac{b^2a^2d^2 + ba\,d^2 + b^2a^2d^2}{(ba-1)^2}$$

$$x - \frac{ba\,d}{ba-1} = \frac{ba\,d^2}{(ba-1)^2}$$

TM

$$x = \frac{(ba \pm \sqrt{ba})\,d}{ba-1}$$

$$= \frac{ba \pm \sqrt{ba}}{ba-1}$$

$$\frac{\frac{a}{b} \pm \sqrt{\frac{a}{b}}}{\frac{a}{b}-1}$$

$$\frac{a \pm \sqrt{ab}}{a-b}$$

$$a : x^2 :: b : l - x^2$$

$$a : b :: x^2 : l - x^2$$

$$x^2 = \frac{a}{b}(b - x^2)$$

$$= \frac{\sqrt{a}\,(\sqrt{a} \pm \sqrt{b})}{a-b}$$

$$= \frac{\sqrt{a}}{\sqrt{a} - \sqrt{b}}$$

$$\frac{a \pm \sqrt{ba}}{a-1}\,d$$

114 $\alpha : 6 :: x^2 : (l-x)^2$

3(275
91.5

Lamp 210 110

TAF

134 ~~930hms~~ on Lamp

164 on 930hms

$\frac{250}{3} = 83.3$

Regulator	Lamp
245	121
254	125
261	129
265	134
270	136
280	141
283	145
290	150
295	154
305	162
295	158
290	153
283	151
275	146.5
268	141
250	128

T8

Regulator

258	133
265	140
275	1465
	1475

283 151

Broke the circuit

282 151

Broke 240 circuit 122

240 120

250 127

270 138

After some minutes lamp on

lamp rotted no change 142

250 130

120

starting machine

70	24
80	30
90	35
100	40
110	45
130	55
140	60
	65
160	75
190	90
200	96
210	102
215	108

Effort to Return & M.F.

121

starting effort	250	129	
	230	115	
	210	95	22
	200	89	
	190	80	FAP
	180	65	26
	170	60	16
	160	50	8
	150	42	0
	140	38	
	130	30	
	120	26	
	50	22	
	30	10	
	20	8	
	10	6	

122

I am seeking to account for the irregularities observed in the lamps. I thought perhaps the lamps might lower their resistance after a time. It may possibly be in the clamps leading to the lamps.

Mch 30 1898 rae

Lamp 810 123

25-7/3 Volts

12-32 132 TAE

12-36 135 TAC

~~267~~ ~~142~~

25-8/3 Volts 138

~~7-10~~ ~~171~~

Lamp 809 cold

25-8/3 volts

1-10 171

1-18 25-3/3 Volts 168

165

285 Volts — 152 = 0
on lamps — 152 = 0
287 Volts — 162 = 0 TIG

---

175 = 0 on 93.5 Ohms

Regulator — On 93. Ohms

287	175
300	181.5
275	168
262	158
250	151
240	145
230	138

Taken off resistance for some minutes

230	141

Made better shot

126

New adjustment Galvo's 127
Regulator On 93 Shunt

275	218
300	235 Tap
250	197
240	191
260	206

Waited a short time

265	208
280	223
200	158
190	150

$\frac{2 \text{ cells}}{3}$ Volts

191 on bump

54 • Photo

Tag

130

280 ÷ 3 = Volts

11.1/4 seconds

199 on Compo

TAG

131

132

$\frac{300}{3}$ Volts.

20 1/3 candles
21.75

222 on lamp.

222)235(1.06 Ohm
222
1300
1332

106)443(4.150)33.000(8.
424
190
106
860

415

133

$\frac{290}{3}$ Volts.

16.25 candles

215

TD?

134

312/3

29 candles

63.5

235 on lamp

250/3 Volts

178 on lamp

5.5 candles

TAG

135

BG 204/3 Vol

27

131 on lamps

212/3

111 candles

139 on lamps

TMR

137

138 $\frac{22}{2}$ = Volts

150

38:12 5 Photo

Fibre coated with 139
Plumbago
$\frac{150}{5}$ = 60 Volts Brand rule

228
144 ww 93 TAG
13.5 candles

140

$\frac{185}{3}$ Volts

61.6 Volts

235

12.25 candles edgeways
15 " broadside.

235 : 146 : : 93

93

438

1314

235) 13578 (57.7 Ohms

1175

1828

1645

1830

577) 16800 (291

1154

5260

5193

670

57.7

2912) 32000 (11.3

2912

3880

2912

9680

$\frac{190}{3}$ = 63.3 Volts Screw coated with plumbago 1/4

242 on Lamps

244

19 candles Broadside

16 candles Edgeways

15 on 93.

TM

243 : 150 : : 93

150

4650

93

243) 13950 (57.4 Ohms

1215

1800

1701

990

574) 75830.0 (3003) 32000 (10.6

1722

3630

3444

1960

3003) 33

16

16

176

142

24.5
200
4445
556
3

255 : 150 : 93 :
150
4650
93
255 | 13950

4.1445
2.4065
1.7380 54.7 Ohms

66.6 1.8235
1.8235
44.3 1.6464
comp 54.7 8.2620

3.5554
4.5185
.9631
1.3617
2.3248

~~2 to 1~~
3600
9.1
211 Candles

2no 1 Nails
66.6

Silver coated with Mendoza
Broad side

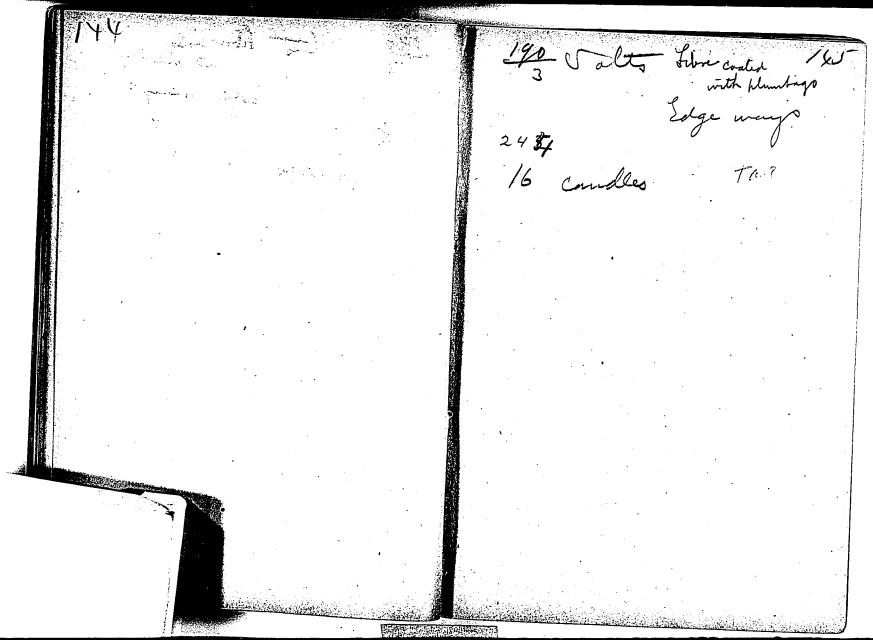
255 on Comp
25.5

TR?

24.5 candles Broadside
20. candles Edgeways

3600 ft lbs.

143


144
1/20
3
Salts
Fibre coated
with Numbings
Edge wavy
24 87
16 candles
TAP

146

147

Lamp No.

R =

Repeat

The carbon slightly inclined

142 on lamps

$\frac{274}{3}$ Volts

T.A.P

11h 26' 950 grains

11h 28' 30" 940

152

$\frac{290}{3}$

$\frac{290}{3}$ Volts

148

148

Turning lamp

90°	~~5.7.85~~	~~53~~ 53.55
80	~~5.6~~	53.58
70	5.3.41	
60	5.2.12	
50	5.2.12	
40	61.12	
20	49.~~15~~7	
10		
6		

149

Regular No. 201

Candles 17.5.18

Deflection 275 +19

Time H, M	
2-3	93 Volts
2-4	Started Calorimeter
2 9	19°2 C 24°8
2 14	~~49~~ 29°8
2 19	35°0
2 25	35°

35°
19.2
15°8 C rise

125.5 grammes water and copper vessel

150

772
9
5 6 7 4 8
1 3 8 9
2 7 6
8 3 4 0
9 7 3 0
2 7 8 6
3 8 3 6 4 6

.002204
1255
.002
2510
2510
2761 0

3836) 33000 (8.6 per H.P.
30688
2312 0
1390

Time
2-36

Deflection 280

No. of Cu. vessels and stirrers 103 Revolutions
With Paint 83
20 Cubes & Stirrers.

5 1390 pounds
276 days

1255
83
1172
2.2
2344
2344
2578 4

1389 per 24
25
9723
6945
2778
34678

152

164 : 198 :: 91

91
198
1782
1018

164 | 18018 | 109.9 Ohms

164
1618
1486
1320

1099 | 2580000 | 2350 Watts
2198
3820
3297
5230

March 17

Comparison of galvanometer 103
with measurement of foot pounds
with calorimeter measurement
Small loop carbon

Time	Remarks
	91 Ohms in line for comparison with coil by shunt.
12-4 P.M.	Engine stopped
12-10	" started
12-11 30	19.0 Ammeter reads 100
12 13	230 Volts Battery
	$\frac{230}{3}$ = 76.6 Volts
12 17	198 on 91 Ohms
12 18 30	20.4 C
12 19	Started
12 20	D = 164
12 24	23.7

3.3

154

H_2O

Cu

31.3 l
26.4
169 Rise
+ .1 Correction
11°

Glass 33.8 grammes

.103
.2
206
206
.2266 C.

1320
13190
13190
152990.
267
1070330
91740
305886
20 | 4082442.0
−2041.
Heating 16
2057 ft lbs

.2266
095
11330
20394
.021517 &
150152
43034
21517
107583.
21517
323.01 | 1204 for 12 minutes
16.1 for 1 minute

Time	Remarks	155
P.M.		
12h 25	D = 164	
12h 26	$\frac{328}{3}$ = 76. Volts	2°8'
12h 29	Thermo. 26°5	
20	D = 164	
	76 Volts Tal	
12h 34	29°	2°5'
35	169 = D	
	76.6 Volts	
12h 39	31°3 Stopped	2°3'
12 42	205 on 91 Thms	
	76.6 Volts.	
12 59	31°	

1319 grammes
103 Copper should be
1216 grammes H_2O

Photo 58.6 ft 15 candles
Results Calorimeter 20557 ft. lbs
Galvanometer 2300
Over

60 | 20.81 | + 60 to be added since the weight alone of the vessel should have been taken at the start

34.7

2115.7 | 2350 | 1.11

2115

2350

2115

2340

Calor. 2115

Galvo 2350

Ratio 1.11

Temp. starting 20°.4 = 68°.7 F

finish 31°.3 = 87°.9 F

Cooled in 20 minutes 0°.3 C = 0°.52 F

204

9

5 | 1836

367

32

687

313

9

5 | 2797

25

32

877

3

5

5 | 2

March 17 1880

Large loop

Calorimeter comparison with Galvanometer

127

Time	Remarks
P. M.	
9-39	204 on 91 Ohms
9-43	72.65 Lamp Alg.

TM

IJF

778
10.6
4668
778
8246.8

1165 kilo 10.3
2.2
2330.
2330
25.63.8
8246
15378
10252
5126
21504
10 | 2213.4.4.98
2213. ft lbs
22
2235

174 : 2.00 :: 91

174 | 182.00 | 104.6 ohms
2.00
500
396
1040

774 Volts

104 | 265.000 | 2530
2092
55.80
52.36
3508

2235 | 2530 | 113.2
2235
2950
2235
7150
6765
4450

Result Calorimeter 2235 ft lbs.
Galvan. 2530 ft lbs.
Ratio 113.2
Temp 71°35 to 81°95

Small carbon

IJ

TM

Time	Remarks	
10 P.M		
10 - 1	71.°35 ✗ Started	
10 - 3	173 ohms temp	
10 - 5	172 ohms temp	
	231/3 = 77 Volts	
10 - 6	76°.65 ✗	76.65 - 71.35 = 5.30
10 - 7	173 - 175	
10 - 9	174	
	235/3 = 78. Volts	
10 - 11	81°.95 ✗ Stopped	8195 - 7665 = 5.30
10 - 13½	200 ohms 91 Ohms	5.30 - 1060
	12.47 Grammes H_2O	
	1165	

Ce

81.6 Volts

294.00

190 : 216 :: 91.
91
216
1944
1944
91 | 9856 | 103.4 Ohms
190
810
190
560

103.4 / 294.00 | 2.84
2068
8720
8272
4480

28.40 ft lbs

Small Carbon 161

TR9

Time	
11.48	56° 85°
12-00	66° 85°
12-2	232/3 = 77.3 Volts
	175 on Lamps
12 5	Stopped the engine

Small 2 brass No 853

Time	Remarks
12h 19'	294/3 =
12h 22'	245/3 81.6 Volts
12h 23'	6009 7 Started
12h 26'	244/3 81.3
12h 27'	67.3
12h 28'	189 on Lamps
	244/3 81.3 Volts

67.3
60 9
6 4

798
60.9
18.9

Correction 3
19°.2

19.2
772
384
1344
1344
1482.4

18.9
772
378
1323
1323
1459.8

2.62
29182
87546
29182
15 | 3822842 ft lbs
2568
25
2593 ft. lbs.

H_2O Water 1.275 Kilo
Can 82
H_2O 1.193
12
2386
2386
2.6296

2593 | 2840 | 109.5
2593
24700
23337
1363 0

Time.	Remarks	163
12h 33'	73°.55	
	246	T.C.S. 232, 240, 492, 246 — 73°.55, 6.3, 6.25
12h 36'	194/3 = 84.6 Volts	
12h 38'	79°.87 Stopped	79.8, 73.55, 6.25
	216 ... 71 Ohms	
12h 41'	332, 261, 93	
	246/3 = 82 Volts	
		Wt. 1.275 Kilo
12 48	79° 2	
	Calorimeter ~~2[illegible]~~ 2286	
	Galvo 2840	
	2286 | 2840 | 1.24	
	2286	
	55540	
	45772	
	9680	

March 18 Tal

Tried a small loop in air. 192 = Deflection, placed the lamp under water 192 = D or as near as I could judge the same. This shows that the temperature of the gloves has very little effect on the resistance of the carbon loop and consequently the ~~heat~~ amount of energy given off from the loop. This the reason is probably that the carbon is of so high a temperature ~~that~~ say 2000°C then 50°C change in temp of surrounding will change the carbon only 2½% or as its resistance falls ⅔ from the original the change will not be more than 1% to 2% considering that the last changes in resistance

1616

Tried the deflection of the line To H.R. Galva = 246
Placed the wires around the lamp direct = 246
This shows that there is no fault in E.M. 7
Next change batteries

Tue 16

Internal resistance 4 cells

20 Ohms	5 Ohms each
Old set	320 = D
Old set	310 = D
Fresh cells	320 = D
Fresh cells	321 = D
Old cleaned	311 } 3 clusters
	316
	319
	320

6300
2
12600
2
25200
6300
18900

100
200
400
500
1600
3300
53 00

25200
54.5
126000
1008
252
13734000

18900
73
567 00
1323
3727

6300
1600
9700

291
47
2037
1164
13677

292
47
2044
1168
13724

Test of galvanometer

how much to use TH

Resistance	Deflection	Product
25200	54.5	1373400
18900	73	1379700
600	109	1373400
6300	218	1373400
4700	291	1367700
	292	1372400
	2	

O.K Zero point changed

170

761
66.8
9.37

1300 Grammes
82
7218
.0022
2436
2436
26796 lbs

778
9.3
2334
7002
7235.4
268
57880
4351.0
1447.0
19400
1940
.19
1959

Wt of vessel 82 grammes

171 : 200 :: 91
200
171 / 18200 (106.4 Ohms
171
1100
1026
740

106.4) 259000 (2430 ft. lbs
1064
1560
1278
4620
4256
3040

1959) 2430 (1.24
1959
4710
3918
7920

Small Loops

7.5

Time.	Remarks
P.M.	
11-37	D on Resistance = 91 Ohms 201 High resistance newly arranged 205 = 215 225 2495 see page 167
11-40 +30"	Start! 66°87
11 41	171 on Lamps
11 42	172 205 = 215 H.R.
11 46 30	71°45 172 173 on lamps 205 = 215 71.6 Volts
11 50' 30"	76°1 198 on resistance 199 Total Weight 1 Bos grammes 0 = 0

71.45
66.8
4.65

761
732.5
28.6

Training Small corps
TLG

178

95.205 × 5.1

5.1
205
1025
95
95.2

110 Ohms

278
889
3890
2334
6224
6496.30
266
38976
38976
12992
1729936
17304

683 Volts

110) 2060 (18.73 Volts
110
950
880
770
300

1734) 1873 (1.078
1734
13900
12138
1762

1.292 Grammes
83
1.209
2.2
2418
241.8
2.6598

175

Test by means of resistance in line with the lamp

Fig

Time	Remarks	
a.m.		
9-42'	Resistance of in line 51 Ohms	
9-50'	68°55 Started	
	891 301	7255 / 68.35 / 436
1-55'	72°55	
1-57'	205 Lamps	
1 58	95 on 51 Ohms 300	76.9 / 72.55 / 4.05 / 470 / 8.35
2h	76°9	
	1292 Grammes	

176

91 : 213 :: 45.1

91 | 7000 (1055

Ohms 71 Volts

223.200 (2116 ✓

211.0

12.30

10.55

1750

1055

695

Galvo.

1266

53

1183

2.2

2366

2366

2366

13.15

778

10520

9205

92.05

100.30.70

26

6018.0

20060

15 | 260.78 (17.38

15

110

105

58

75

128

17

1755 | 2116 (1.20

1755

3610

3510

1000

838

7065

13.15

Test small loop

177

T66

Time	Remarks
2-23	45.1 Ohms in line
2h 29'	70°.65
2h 30	213 on lamp 91 on 45.1 Ohms 291 213 078 302
2 34	75°.17 751 70.65 47
2 37	215 Zero 2 to left 208-219 = 213 on lamp
2h 39'	79°.6 796 751 45
2h 41'	70 on 45.1 Ohms
2h 44'	83°.8 838 796 42

1266 grammes

Galvo 2116 ft lbs

Calvo 1755 " "

Ratio 1.2

Temp start 70°.65

end 83°.8

178

90:207::45.1

45.1
207
3157
902
93357

93357 / 1033.7 = 90 Volts

1033.7 Ohms

1 Leclanché Total 2 V.

1.2 1 7
1 4 3 4
2.6 7 7

1970
1.8
1988 | 2092 (1.05
1988
10400
9940
4600

10.3
5.2.1
14.2
7 7 8
7136
994
994
110476
2.68
8 8 8 3 6 8
6 6 2 8 2
2 2 0 5 4
15 | 29565.88 (1970
15
145
135
186
105
8

179

Seek small loops

+19

Time	Remarks	
P.M.		
3.15	52°.1	
3.17	205 on Lamp	
3 19	90 on 41.5	56.85
3 20	56°.85	52.1
2 22	210 on lamp	4.75
2 24	210	61.6
2'25'	61.6°	56.85
2.30	66°3	4.75
	1300 Grammes H2O Eq.	60.3
		53 =
		4.7
	1988 ft. th. calorimeter	
	2092 " " Galvanometer	
	Ratio 1.05	Temp at start 52°.1 and 66°.3

70·3 Volts

89 : 211 :: 45·1

211
45·1
9502
89 | 95161 | 1068 Ohms
89
616
534
82°

1068 | 1 grm | 2050 ft lbs
2136
8400

1330
83
1251
2
2502
2502
2752 2

1411
778
1128
887
10969·8
2·75
54845
76783
21938
15 | 301647·5
2010
20
2030

2050 Galva
2030 Calorimeter
2030 | 2050 | 1.01
2030
20

Small carbon

TAR

Time	
A. M.	45° Ohms in line
3 - 55	52° 35 Standing
4 = 20	53° 75
4h 22' 5"	53° 75 Started
4h 24'	211 on Galvo
4h 27' 5"	58·6
4 30	211 on Galvo
	89 on 45·1
	63·35
4 35'	0 = 0
	89 on 45·1
4 37' 5"	67·85
	1384 Grammes

58·6
53·75
4·85

63·35
55·6
4·75

67·85-67·85
0·375 63·35
1410 45·0

45° Ohms in line
Tents air 62°·57

Over

182

A. M.
43-5

Temp air 63°3

183

TAR

Galva. 2050 ft. lbs
Calva. 2030
Ratio 1.01
Temp. start 53°75
15 minute Cond 67°85

I want this series 185
TAE.

Try three measurements with shunts
and with resistance in line

(3) start below temps. air and time
then run above temps. air as number
and times 5° 10° 15° about

(2) Try very hot and cold

(2) Try below 15° to temp air
~~and~~ Temps air to above 15°.

(1) Try stirring constantly 15 minutes
and no stirring until end
15 minutes Tried 35 min

95 : 259 :: 91.4 : 1737

91.4
1036
259
2331

95 | 23672.6 (249.2

190
467
380
872
555
1 70

413000 (1737
2492
18380
17444
9360
7486
18740

658 / 54.6 = 11.2 p

778
112
1556
778
778
871 3.6
267
60991
5.22 78
17726

1295
82
1213
2.2
2426
2426
2.6686

15 | 232.87 (15.50
15
82
75
76
75
134

1565 ft. lbs

1565 | 33000 (21
3130
1700

1737 | 33000 (19
1737
15630

Lamp No 9.25 R = 450

Flame

Time

10.40	91.4 Ohms in resistance
10-12	259 in 91.4
11h 14'	54.6
11h 15'	290/3 = 96.6 Volts
	95 on lamp
11h 24	62.2 F
11h 25	94 on lamp
	282/3 = 94 Volts
11h 29'	65.8 F
	1295 H_2O Vap
1/40	Temp in 68°5
12	67.5

622 − 56.5 = 7.6

65.8 − 62.2 = 3.6

188

103 : 170 :: 695

170

48650

695

103 | 11815.0 | 114 Ohms

103

151

133

485

3 | 170

56.6 Volts

114 | 142000 | 1245 ft. lbs.

114

280

228

520

456

640

189

Lamp No 85-3

R = 172

Small carbon

Tel

Time		
12-30	54°85 7	67.5 67.5 54.8 12.7 12.7 : 79.6
	D = 275. 41.6	
34	170 on lamp	58 54.85 3.15
12h 35'	68°	
12h 36'	58°4	60.8 58 2.8
12h 40'	60°8	
12h 41'	98 103 on resistance 108	
	D = 0 200 Ω coil = 64	63.7 60.8 2.9
12h 45'	63°7	
12h 47'	98 103 on resistance 104	66.5 63.7 2.8
12h 50	66°5 Started each five minutes.	
12 52	about 170 on Lamp	

74.35
54.85
19.50
778
1560
+365
1365
1517.0
2.73
4551.3
106197
30342
35 | 4141.683 | 1193
35
64
35
291
280
116

1825
82
1.243
22
2486
2486
2.7346 Ohms

1195 | 1245 | 1.042
1195
5000
4780
2200

Ratio 1.04

Fine

1 1/2 5-5' 69°1 Tan 69.1 / 60.5 / 2.6 — 78.6 / 69.1 / 2.5

1 — 71.6 Gehl

1-4 170 on lamp.

1-5 74°357 — 74.35 / 71.5 / 2.85

1325 Grammes

69.5 Ohms in line

1 3/5 65°7 Temp° air

1288
82
1206
22
2412
2412
2565 2

74555
333
19125
778
154000
134775
134775
1497650
2465
74880
89856
29952
35 | 39686.40 | 1133
35 | 11
46 | 1144 ft lbs
35
118
105
136

1195
1133
62 6%

1133 ft lbs no stirring
1195 " " stirred

When the calorimeter is not stirred a hot layer of water covers the top which gives off heat faster than if the water were all of the same temperature. That is the calorimeter will show less

Lamp No 853
R = 172
small carbon TAP

Time	Remarks
2 - 13 p.m.	55.3 started D = 170
	No Stirring
2 47	D = 170 on lamp
2h 48'	- 86° before stirring
	74°55 ¼ after stirring stopped
	264 -260 5 D = 275 Total
	1288 Grammes

243 : 248 :: 91.4

91.4
992
248
2832
226672 (932
2187
797
729
680

358.80 (3850 ft lbs
271
7920
7456
4640
6

75°05
58°65
16.40
778
1312
1148
1148
1275.92

1361
82
1279
2558
2558
2781 38

1275.9
2.8
12759
102072
25518
3585279
36
3621

Color 3585 ft lbs

3621) 3850 (1.063
3621
22900
21726
1174

Lamp No. 85·3
R = 172
T&G

Time	
3h 59m	270 90 Volts
4h	58°65 Started
4 1	231 ? Yale
4 2	238
4h 5'	67°7 Stirred each minute after
4 7	242
4h 8	244
4h 9	245
4 10	75°05 Stopped Scale moved
4 11	243 on lamp &
	248 on 91.4 Ohms
	244
	270 = 90 volts 1361. Grams

67
58.65
835

75°5
67
8°5

day 3850 ft. lbs. Galvan

7215
55
17.05
7.778
136.40
1.7935
1.8935
1326.409

1315
82
1233
22
2464
2463
2712.3

1326.0
2.71
1326
9282
2652
359 34.60
36
36.29

3629

Lamp No. 855
R = 172
TNG

Time	Remarks
4 34	55°.17 8
4 35' 30"	Started
	270 ÷ 3 = 90 Volts
4 33	242 = 241 for gas connection
	242
4 40' 30"	646
	72°.15
4 45' 30"	246 δ = +1
	245
	1315 Grammes

Lamp No. 618 perfect carbon gray steel like lustre no change or blackening has burnt 1000 hours also sign of irregularity at red heat.

11 42 16
11 18 35
23 49
60
1380
49
1429 + 600 2029

11.37.5
11 16 35
18 30
60
1080
30
1110

1350
1280
170

15 : 156 :: 2a

15 | 312 | 2
30
120

208 candles

2029 grains
1350 grains =
1220
130 grains

2029 | 130 | 156 candles
130
729
650
790

March 21 199

Time	Remarks	TAG
a.m.		
11-10	Regular lamp No. = 618 R. = 150	
	Moderately clear globe Broad side. General arrangement in Photo. Broad side of lamps	
"	88.2 Lamps in receptacle	
"		
11-18-35	M with Bunsell-balance 1350. grains	
11-37	H.R. Galvanometer 65 = 20 volts 275 = E.M.F. 3 = 92.66 Volts 173 = 20 amp. lamp 170 = 2 on 88. 2 Others	

200

60.78
60.62
1.30

Photo 17, 60.7 21 candles
8 candles

173; 170; 89.2

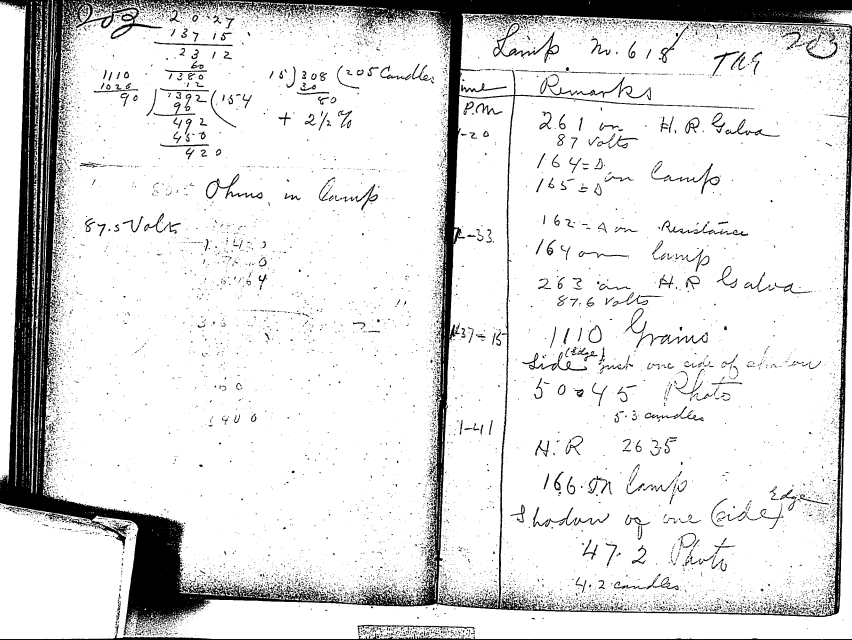
1.9504
2.2006
7.7619
1.9429

87.7 Ohms

92.6 1.9661
1.9661
1.6464
8.0570
3.6356 4320 ft. lbs.
4.5185
.8829 7.6 per H.P.
15.4 1.1875
2.0604 114 candles

Lamp 618 201

Time	Remark	Tag
2:33	Photo 60.78 20 candles	764 30 1630 avg 154
1 37.5	On scale 1280 grams	
1 38	60.62 Photo.	
1 47	Side 5.3.25 8 candles	(Edge)
	173 on lamp	
	170 on resistance	
	278 on H.P. Volts 92.6	
18 1/2-16	1220 Grams	
	69.2 Ohms in resistance	



Lamp No. 618 TRG

283

Time	Remarks
P.M.	
-20	2.61 in H.R. Galva 87 volts
	164 ± 0 on Lamp 165 ± 0
-33	162 ± 4 on Resistance
	164 on lamp
	263 in H.R Galva 87.6 volts
437 ÷ 15	1110 Grains
	Side (Edge) just one side of aperture
	50 ± 45 Photo 5.3 candles
1-41	N.R 2635
	166.5 N lamp Edge
	Shadow of one side
	47.2 Photo 4.2 candles

20.27
137 15
23 12
60
1380
12
1392 (15.4
98
492
480
420

15) 308 (205 candles
30
80
+ 2½%

Ohms in Lamp

87.5 Volts

204

205

Lamp No. 618 Tag

Time	Remarks
	Brook rd
1.52	58.2
1.53	58.7
1.55	57.4 58.2
1.56	56.80 14 candles
1.56.15	57.22
1.57	57.8
1.59.30	57.
2.00-27	1020 Grains

16.4 mi lamp

$\frac{262}{2} = 8.11.7$

206

107 | 125 | 894
185
4476
758
894
107 | 111750 (1045 Ohms
107
475
428
470

4570
443
1371
1828
1828
104 | 202450 (1946 ft. lbs.
104
984
936
480
416
640

207

Lamp No. 618 T&E

Time	
2-5	2 Candles Brass side 203 on H.R 676 Volts 104 on Lamps. 125 on 894 Ohms

92.9) 256000 (2755 ft lbs
1858
7020
6503
5170
4645
5250

136) 140 (103
136.
400

90.2
103
27706
902
92.90 Ohms

Lamp No. 618 THE

Time	Remarks
P.M. 2-15	228 / 3 = 76 Volts 136 on Lamp 140 on Resistance 49 Photo 5.1 Candles

90.3) 320.000 (3542 ft/h.
270
491
451
3950
361
2380

Santa Fe 618 Trq

Sine

E = 1.5 on Photo
159 on 90 = 6.5 miles
160 on Equip

$\frac{.255}{3}$ = E.M.F
= 85 Volts

2.25 90.2 Ohms

Lamp No 6.18 TAE

Time	
2-31-15	900 Grains
2.32	$\frac{277}{3}$ = E.M.F
2.35	172 on Resistance
	Changed current

Ga 35 Gauss
3977. Gilbs

Lamp No. 618 Tag

Time	
3-16-10	750. Grains
3-12-10	New Centerpiece
	148
	Boyd side Photo. 5 Gr. 85 16.5
3-25	$\frac{270}{3}$ = E.M.F. 90 volts
	170 on Lamp

851) 454000 (533 ft lbs.
425 5
2850
2553
2970

198 : 187 :: 90.2 : x
90.2
374
1683
198) 16857.4 (85.1
1584
1027
9910
374

37
77
259
259
2849

5333) 33000 (6.2 for H.P.
31998
11020

6.2 surface of regulator
11
to give 16 candles
and 11 hp or
6 inefficient.

28.5
6.2
570
1710
16) 1769.0 (111 hp
16 each

Lamp No 618 Regulator

Time	Remarks	Taf
3-27	65.8 Photo	
	3.4 / 3 = S.M. F	
	101.3	
	198 on lamp	
	187 on Resistance	
3-30	65 on Photo	
	64.9 on Photo	
	64.75	37 candles
	65.25	
3-41-38	1370 grams	

27
62

Lamp No. 613 R 190 709

219

Time	Remarks
	Small carbon. Blackened a slight irregularity in the various portions
	795 Grains
4-11-10	44.2 Photo.
	203 Watts
4-06	90 on lamps ~~regulator~~ ~~resistance~~ gauge removed
	92 on lamps
14-049	225 on H.R. Galvo.
	128 on Resistance.

220

221

Lamp No 813

Time	Remarks
	Sides (Edge
4-8	31.2 Photo Wound to
	34.1
	91 on Lamp screw driver
4-12	near lamp
	3 E.M.F.
	Screw driver removed
	92 on lamp
	128 on resistance
	Good zero on both
	galvanometers. 20 cells
4-25	gave 65 sharp
	Resistance boxes =
	90 Ohms

222

Lamp No. 813 223

Time	Remarks
	The magnet on small bridge Galva removed and deflections taken This will make the deflections which follow discordant with those preceding
	Zero
	99 on lamp
	215 on H.R. Galva
4-57	132 on 90 Ohms
5-5-20	500 grains (and 6 changed)
5-7	Side (Edge) 35.5 - Photo

224

Edge 35.5
1.2

Lamp No. 8.13. 225

Time	Remarks
5-8	97 on Lamp
	212 on H.R. Salmon
	46 # 2 - Broadside
5-10	.213 H.R.
	214

137 : 171 :: 90

90

137 | 15390 | 112.4 Ohms

137

169

137

320

274

560

8281

943

24843

331124

331124

112.4 | 36684 83 | 3246

3372

2864

2248

5168

4496

6720

3246 | 33000 | 10.16 H.P.

3246

5400

3246

21540

5 25 45

5 5 20

20 25

60

1200 25

1225 | 1475 | 1.2

1225

250

395

332

630

581

490

-2%

61.75

63.25

63.1

188 0.0

62.6

26 candles

-2% 25 candles

Lamp No. 813

Time	Remarks	I.P.
5-15	Photo 61.75 Bromide	
	272 H.R. (90.6 Volts)	
	135 on Lamp	
	168 on 90 Ohms	
	137 on Lamp	
5-17	275 H.R.	
	Glass Manufacturers	
	[illegible]	
5-21	63.25	
	63.1	
	274 H.R. (91.3 Volts)	
	139	
5-25-45	.417 grams.	

Calva

92
5 1
184
838
8464
443
25392
33856
33856
3749 5 8.2

135 : 167 :: 885
167
6195
5310
885
135 | 14779.5 | 109.3 Ohms
135
1279
1215
64 5

1093 | 374955 | 3430
3279
4705
4372
333

Test with calorimeter of Galvanometer March 24 1894

Water from Deans well 48°F
all the connections with galvanometer the same as yesterday

Time	Remarks
A M	Lamp No 813 Small Lamp. R 190
11 10	Temp. water in calor 51°3 4 (Thermometer) 62.5
	Temp. air 62°5 51°3 11 2 62.5
	Thermometer warm 75°7
	Calorimeter
11 12	H.R. 276
11 14	135 on Lamp Stirred
11 15	58°87
11 16	H.R 276 = 92 Volts
	135 on Lamp
11-17	Stirred

1241
83
1158
22
2316
8316
25476 lbs

74.75
58.5
15.95
77
1272
1113
1113
12370
254
4948 03
61850
24740
10 | 3141.985 3141 lbs.

3070 lbs. the carbon
3070 | 3430 (1.11 Ratio
3070
3600
3070
530 | 15

58.5
67.3
7.5
66.5
58.8
7.7
74.75
66.5
6 | 8.25
1 37
6.88

74.75
57.3
23.45
772
458
1638
1035
1803.48
25 5
90320
9 8320
36128
46 | 6063.20 (3070
45
106
86

Time	Remarks	231
11-20	66.5 uncertainty about the time one minute disc to the second and minute hand not corresponding	Tare
11 22	Stirred	
11-25	74°75'4 (Stopped)	
	167 on resistance	
	85.5 Sums temps. 60°4	
	0 on sun's resistance	
	1.5 2 so that this must be added	
	1241 Grains Holden Rhs.	
11 46 50	380 Grains	
	147 Lamp	
	17 Resistance Zero adjusted	
	277 H. R Galva	
	63.31 on Photo 39 smaller Error from day light	

232

80.025 thermal units required to melt 1 lbs ice Dillmans

5 | 80.025
16.005
9
144.045
7778
1152360.
1008315
1152675 thermal units

.465 kilo
2.2
930
930
1023 0 lbs

111.067
1.023
333201
222134
111.067
30 | 1736.21
3787 ft. lbs

The ice was fine and quite dry and also had some lamp black mixed with it. It was not given full time to drip.

Calor. 5910
Calor. 3787

3787 | 5910 | 1.7
3787
21230

Time	Remarks (Tail 233 See page 238)
	Experiment with ice calorimeter
	Cu. cell placed in circuit with lamps.
2-43	The outside and inside filled with ice
	Vessel placed so as to catch
2-43	The drip from inside. (Six tubes taken)
	Glass placed under. Grams 129.8
2-47	12 minutes 33.5 grams 7.55
3-26	ten minutes 28 grams 7215
16	10 grams 30.6
	30 20
3 17	40 26 Drop every 19 seconds
	8
	27
	45
3 22	25 seconds
	24 seconds

234

74.9) 443000 (5910 ft. lbs
3745
6850
6741
1090

216 | 182 | 89.31
182
1786
7144
893
216 | 16252.6 | 74.9 ohms
1518
1072
864
2080

Ice Calorimeter 235

Wt Cu plate
14.776 Lawson

3 36 Started

Water running
300 on H. R. Galvo

3.42 Water commenced to drip
Galv. - 302 H.R

3-44 94 drops per minute

216 on Lamp
302 on H.R.

4-1 302 on H.R
216 on Lamp

4-6 Stopped

216)182.0(.842
1728
920
864
560

87.3
.842
1786
3572
7144
75.1406 Ohms

Volts
75.2)100.3(1.334 Webers
752
2510
2256
2540
2256
2846

30)72.19
.02406 Mg
24 mg for 1 minute

1.334)2406(18.0
1334
10720
10672
4800

18 mg. per minute

See calorimeter

Wait until a drop every 25 seconds then it may be assumed with reasonable exactness

#1 187 182 on resistance at 63.7° 89.3 Ohms

15.479.5
10.7172
7219

The cell and leadings were about 1 Ohm

4.35 Weighed Wait 1 Glass 550 grammes
106
444
185
4625 grammes

65.5
47
185

say 465 Grammes

The cells used as standards had changed there E.M.F as is shown by the deposition of Cu.

Note July 1880 The Cu. deposited 18 mg. per Weber for minute shows that the cells were badly charged out

$18^2 = 324$ 2.5105
$19.6^2 = 384$ 2.5832
.0727

84.6 % of results

Sine Lamp No 705
R = 225 Ohms

Time P.M	Remarks
8-26-20	320 ½ turns Read zero M.R 2550 118 on Lamp Procedure 53 bis Edge 51.2 165 In 58.5 Ohms

240

103
103
309
103.
10609
4243
21211
6 2 6 3 6
2 4 3 6
46997 8.7

133 : 154 :: 88.5
154
2540
7080
885
133 | 1628 4.0 | 12.24
133
298
266
324
266
580

122.4 | 469.978 | 3840 | 33 000 | 8.6
367 2
10277
9792
4855
4896
30720
2280.0
140

8.6 per H.P.
15 candles each

14
86
14
344
86
1204

24/

Fibre lamp No. 705.
R = 225 Ohms

Time	Remarks
	58.5 Photo
9-40	309 H.R 133 on lamp 184 on resistance
941	265 grains
	8½ per H.P. 15 candles each 14 candles all round
	306 H.R. 132 on lamp 57.5 Edge 58.3 Photo 57.9 Edge

265 : 280 :: 168 :
280
13440
336
265) 47040 (177
265
2054
1855
1990

182 : 177 :: 885
177
6195
6195
885

182) 156645 (86) 345000 (4244
1456 324
1104 210
1092 172
125 380
344
360

page 232

112067 .684
15 22
560335 1368
112067 13680
40 1681005 15048

4202 ft. lbs

Ice Calorimeter March

Time	Remarks
8 a.m. 9.25	Started.
9.28	Drop.
	265 N.R = 88.3 volts
	182 on Lamp
10-5	~~10~~ Stopped

Weighed in the morning 790 grammes
106
684 grammes

The ice was cleaned for this and some larger lumps introduced.

The deflection on resistance calculated

Plating Cu

Time	Remarks
	Ex. made by Yale
7-36	E.M.F. $\frac{280}{3} = 93.3$ Volts
	Plate 15.4915
	165 in ~~resistance~~
8- 6	stopped (Coil .64 Ohm
	R = 88.5 Ohms
	Coil = .5 Ohm (Total 89. Ohms)

Plate 16.0700
15.4915
10.5 | .5785 (5.51
5 25
53 5
52 6
10 3

89 | 93.3 (10.5
89
430

30 | 5.51
.01833 mg.
in Weber per minute.

246

Ice Calorimeter 247

9-10	One drop in three minutes
	Load zero
	30 volts 65 R.H.
	Temp cells 57° F fair condition
9-45	Started
	H. R. 290 L
	292 R
	200 m Lamp
	Temp about 58° F
	198 on beams
	0 Low resistance 2 R
10-15	Zero reset
	195 on Lamp

9cc Calorimeter

Time	
10-5	The shunt cut out by wire and current passed through tuesis - tance
10-8	285 L H.R
	287 R H.R
10-5	172 on resistances
	Temp coils. 53°7
10-10	178 on resistances
	292 R on H.R
	172 on resistance
10-14	287 L H.R
	Good Zero
	20 cells. 65 L 6575-R
10-17	293 R
10-19	198 on lamps

250

9cc Calorimeter 251

Time	Remarks
10-40	198 on lamp
	292 R on Galvo
	Used zero
10-51	172 on resistance
	2872
10-55	changed.
	Wt cu vessel 62.5 grammes
	Wt Glass + H_2O 1116.5 gm
	106
	H_2O = 1060.5
11-3	Wt glass + [illegible] 110 grammes
11-5	Glass + H_2O 127
	110
	H_2O = 17 Grammes

212

.0423 in free annual loop

3/2/87

95.6 volts

198 : 172 :: 881

172

1762

6167

881

198 | 151532 | 76 | 406000 | 5342 Ft/lbs.

1386

1293

1288

380

260

228

320

304

16

Time

9cc Calorimeter

213

11-10 Placed glass vessel weighing with H2O 127 grammes or 126.75 under

$CaCl_2 \cdot 4H_2O$ 287 grammes

625

2245 Wt H_2O

1015

17

1252.0 Grammes H_2O

11-15 172 on Resistance

287 & 4 R

198 on Lamp

254

20) 348.25 (
017.41 grammes per minute

.0174
2.12
345
345

.0174 mpf 232
112067
10358
322201
89056
33621
929216 61

17.4 19.5

302) 380 (1.22
302
780
604
176

Gee Calorimeter 255

11:23 196 on Temp
255 M.R.

11-24 [illegible]
255 M.R. [illegible]

11-27 Temp rise 58°F 53.5 53.25
195 on Temp
255 M.R.

11-30 Stopped [illegible]
Weighed
Wt gun 420 475
55 1267
3492 grammes

256

1.765
2.2
3530
3530
105 | 3.8830 | .037
315
733
735

112067
.037
784469
336201
4146479

4146 ft lbs

Result

			ft lbs
Calor	20 minutes	4292	
	105 "	4146	
Galvs		5342	

4292
4146
8438
4219

Ratio
5342 | 1.26
4219
11230
8438
2792

Time | Ice Calorimeter | 257

11-40 Cu vessel taken out of glass put back

11-45 Resistance 88.1 Ohms

wt cu H_2O 345
287
58

2-10 Wt glass vessel 67 ounces
placed and 20

Wt glass cu H_2O 542
3 P.M drops every 45 seconds 475
87
345 x 25
1725
1252

60
45
105 Total Wt 1745 25
20
67 1765

40 | 17833
.01958

90 | 95
1.055) .01958 (.0185 mg.
10555
9030
8440
5900
5275

Time Cu plating

3-12 175 on resistance

3-25 65 temp resistance

352 Stopped (40 minutes)

170 on resistance
89.5 Ohms
285 on H.R.
95 Volts

16.8533
16.0760

.7833

260

Seat of cells

261

P.M
4-22

Head 205
198
195
195
205
988
197.6

Fresh cells 205

Bottle 2:580 Litres
49
23220
10.326
Kilo 125.420 Litres
or 2.2
25284
25284
278.124 lbs

278
778
2224
1946
1946
216.284
5.65
1084420
1297704
1081420
12222.01 | 81466
120 | 13577
22
15
70
60
100
90
10

95043

3. Ohms Calorimeter

345 on machine
2
all open

11-20	Started	
	63.67	69.25
11-26	860.5	63.67
		5.58
11-35	69.25	

1/50 Calorimeter
43
6
258

1250
83.3

8 | 307000
102000
17
119000

Dynamometer

944	948	949
1 003	1000	1000
2 1947	1948	1949
972.	974	974.

Edison

971 no
973 without load
972 average

872 average with load

10.92 corrected gage pressure
188 for engine volts

8736
8736
1092
20529

102.648 ft. lbs. Degree
95043 ft lbs calor

2617

108
60
2160

80 · 218 · 216
315
1728
216
432
47 98.8
94.18 volts

3 | 3½ and
130600

102646 Hefley Dyne
Upton

216200
71
216200
15794
15 | 154.10.200 | 102.000 Hefley,
15
41
30
110

Dyne monometer 2617

2-5 970 lbs running
free
69.47

2-15 started
870 very good

2-30 76.5 76.5
20 lbs 50 60
218 71

268

Test of Pony with 269
Edison dynamometer

March 30

11 feet

975 revs

~~928~~
927
975
~~976~~
1074 5
5

Dynamometer

1130 revs full speed of machine

6 lbs at

12 3/4 feet

978 revs

907 on Dyne.

12.75
6
76.50
978
60020
53355
69615
7500700

2052 Regulon Speed of Belt

1130 | 978 | 2052 | X
978
16416
14364
18468
1130 | 2006856 | 1775
1130
8768
90 #0
7290

887 Dyne
980 revs

13 feet

7½ lbs

13
7.5
68
91
97.8
960
7820
8802
95844.0
15007
20844

Benj Franklin
13660 Edison

1129
907
587
20

18660
20
2 | 27360
13680

$\frac{187}{200} \times \frac{4}{2} \times 108 = 202$

187
108
1516
187
20216

$\frac{1655}{200} \times 4 \times 108$

30) 165.5
3.31
108
2645
331
3.5745

3.574 5

6.05) 3.574 5 (.590 ohms
3025
5490
5445
45

.59) 11.6 (19.6 mg
59
570
531
390
354

fresh cell

Cu. deposition

Yale Ex

4 cells of Darnell gave
200 deflection 1.0

2 cells of Bicromate
gave 187
each cell 2.0216 Volts

Wt. Plate 17.9109

4-35 Started 6.05 ohms 165-166.
4-40 Ammeter
4-47 Temp bath 72° F
5-05

18260
17910.9
30) .3491
.01163
11.6 mg

277. in inche 8 gallon

10 gallon

20

28 inches high

135 sq inches base

13 1/4 inches

9624
7000
67348000 H. lbs

11.2

6841
7000
47887.000
2
95774000 18 lbs H₂O

18 | 95774000 (5.32 2 0000

90

57

54

37

38 | 5320 (140

33

202

198

40

1 HP. 2⅔ hours to send off 1 lb of H₂O in form of gas

5775
155
9
1395

34462
1395
172310
310158
103386
34462
48,074,690

48,000,000 ft. lbs. given off in burning 1 lb. of H.
96,000,000 ft. lbs. 2 lbs
or to make 18 lbs of H_2O.

18) 96000000 (5,333,000
90
60
54

5,333,000 ft. lbs to decompose 1 lb of H_2O

33) 5333 (161
33
203
198
5

151 H.P one minute to decompose 1 lb of H_2O $\frac{161}{60} = 2.67 = 2\frac{2}{3}$ hours

1 H.P $2\frac{2}{3}$ hours

1 lb of H_2SO_4 contains 64% of H_2 acid at lead concentration ~~of~~ concentrated contains 98% of acid

278

of contains 64% of acid

36% of H_2O in dilute acid to make 1 lb of acid at 98% how many lbs of acid H_2O must be driven off

1 lbs. of H_2O about for 3 lbs of acid

5,000 lbs of H_2O for 15 000 lbs of acid

500 H.P working all day to concentrate as much as one still

Pt. stills will concentrate 24 tons

20 000 lbs of brown sulphuric

20000
.78
2000
1560 pounds

15 000 lbs of 78%
15,000 lbs of concentrated acid

282

112 · Ramps

105 · Ohms

120 on 105

~~105 ||||~~ !

112 ; 120 ; 105

105

1260

120

112 | 12600 | 112

112 | 28.5

140

112

280

83.5 Ohms

283

112 | 83.5 | .746

784

510

498

720

720

~~87~~ .749

67.41

200

83.5 | 19880 | 2381

167 0

3186

2505

6810

6670

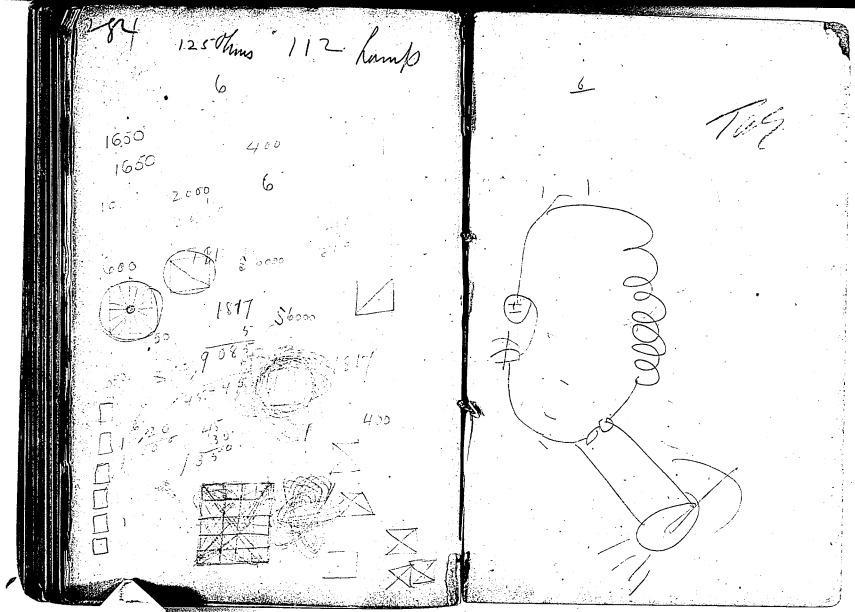
1400

2381 | 3300 | 1.4

2381

9196

9524


84
125 Ohms 112 lamps
6
1650
1650
400
6
2000
1817
6
400
Tues